February 10, 2004

Ms. Kathleen Johnson
Department of Environmental Quality
PO Box 200901
Helena, MT 59620

Subject: CR Kendall Post-Closure Environmental Impact Statement
Effects of Historic and Modern Mining on Sediments and Water Quality
in the Off-Site Mine Area Drainages

Dear Kathy:

Camp Dresser & McKee, Inc. (CDM) is pleased to submit to the Department of Environmental Quality (DEQ) 4 copies of the Final CR Kendall Post-Closure Environmental Impact Statement Effects of Historic and Modern Mining on Sediments and Water Quality in the Off-site Mine Area Drainages.

Please contact me at (406) 449-2121 if you have any questions with regard to this report. CDM appreciates the opportunity to work with DEQ on this project.

Very truly yours,

Darrel M. Stordahl, P.E.
Principal/Senior Project Manager
Camp Dresser & McKee, Inc.

CR Kendall Post-Closure EIS

Effects of Historic and Modern Mining on Sediment and Water Quality in the Off-Site Mine Area Drainages

February 10, 2004

Final Report

Contents

Appendices

List of Figures

List of Tables

Section 1
Objectives

The drainages down-gradient of the CR Kendall Mine site either have been, or have potentially been impacted by historic mining operations. While these impacts are not a direct part of the on-going Environmental Impact Statement (EIS), they are important to understand because any water (treated or untreated) discharged from the mine site and released to the off-site portions of the drainages may be adversely impacted by the presence of contaminated tailings and/or sediments in these drainages.

The objective of the current investigation was to evaluate this potential interaction between water discharged from the mine site and tailings and/or sediments within the upper portions of these drainages located down-gradient of the CR Kendall Mine property boundary. The evaluation focused on the concentrations of the elements of concern within the sediments and soils within each drainage, the current water quality in area surface waters and groundwaters, and the impact of historical mining and milling activities on the drainages down-gradient of the current mine boundary and the interaction that would likely occur between discharged mine water and any historical mining/milling wastes in the drainages.

Section 2
Overview of Mining/Milling Activities

The CR Kendall site is located in the North Moccasin Mining District in Fergus County Montana (Figure 2-1). Mining in the area can be divided into the historical period from 1880 through 1941 and the modern period, extending from 1981 through 1997.

2.1 Historical Mining

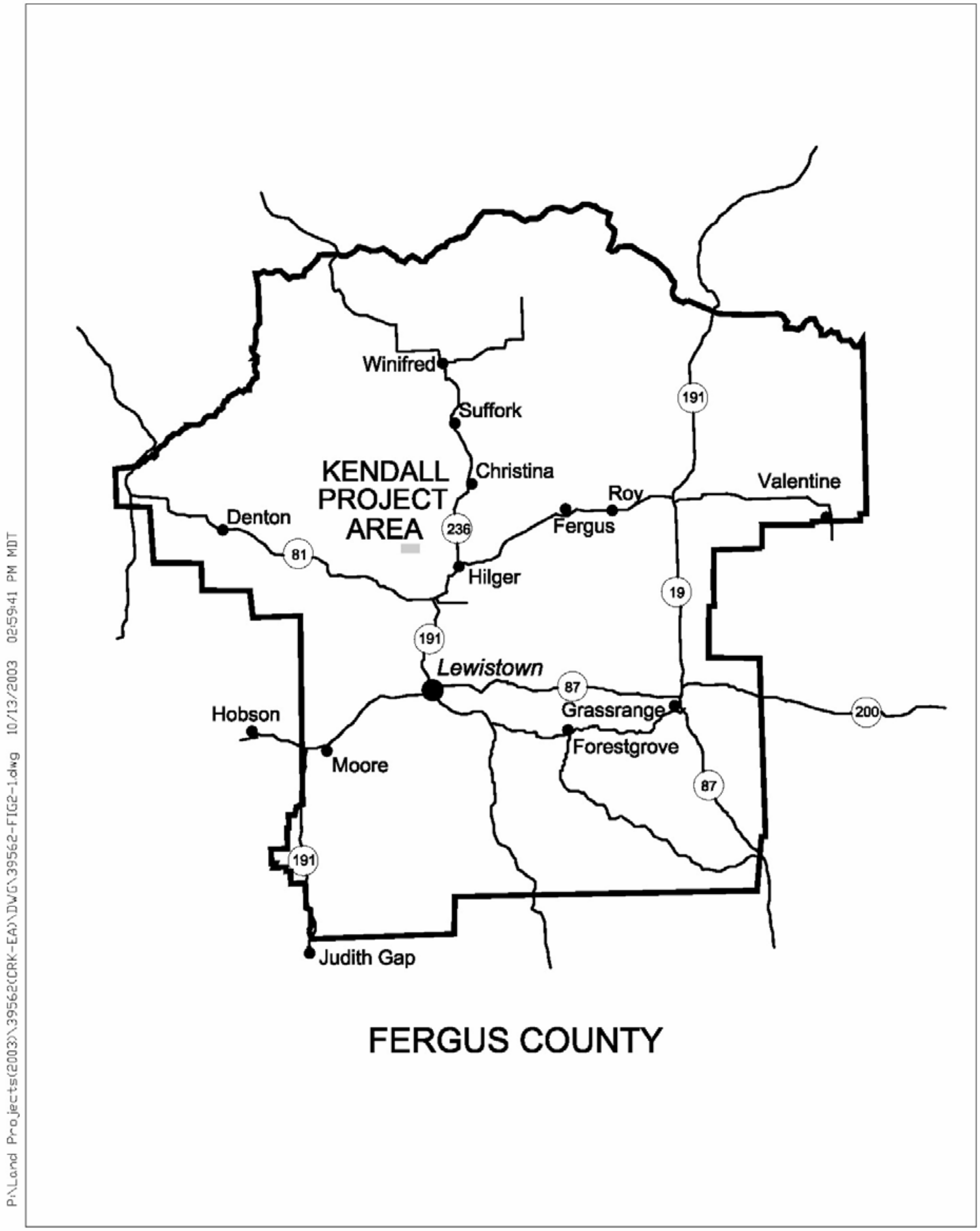
Mining began in what was to become the North Moccasin Mining district in 1880, when "Old Man" McClure staked a claim in what was to become McClure Gulch (~2 miles west of the modern mining operations on the west slope of the Moccasin Mountains). In 1881, the Buchanon Brothers and John Brooks established a claim in Iron Gulch (~1.5 miles west of the modern mining operations). The operations were believed to have been largely placer mines, although an unsuccessful stamp mill was constructed in 1898 (MHS, 1974). The nature of the lode ore prevented economical gold extraction using free milling techniques such as employed when crushing the ore in a stamp mill and amalgamating the gold using mercury. Therefore, it is likely that only a very small quantity of tailings was produced from the Iron Gulch mill before the experiment was abandoned.

Placer operations continued in the drainages west of the current mine site through the 1930s and possibly later. Estimates of the placer gold production from Iron Gulch, McClure Gulch, Bed Rock Creek and Plum Creek range from $10,000 to $50,000 between 1880 and 1933 (Blixt, 1933). Given the low production figures, the mass of tailings produced from the placer operations is believed to be small. No tailings are visible on the air photos in this area.

With the advent of the cyanidization process in the 1890s the economical extraction of gold from the lode ore in the North Moccasins became possible. The cyanidization process involved four steps; crushing, leaching, precipitation, and refining. The mined ore was crushed to ¼ inch mesh and placed in a vat of cyanide solution (3 lbs. potassium cyanide per ton of water). Gold recoveries of 90% were obtained from the oxidized ore. The unoxidized ore and black ore (containing bituminous and organic matter) were first roasted before leaching in order to convert the gold into a form that could be dissolved by the cyanide solution.

Following leaching, the cyanide solution containing the gold was pumped to the precipitating tanks, which contained zinc shavings. The gold plated out onto the surfaces of the zinc particles. The zinc/gold was then placed in a lead-lined tank where sulfuric acid was added to dissolve the zinc, leaving the gold as a thick, black mud-like material. The gold mud was then refined into gold bricks.

The spent ore from the leaching vats was washed through holes in the bottom of the tanks to the dump. The tailings from the cyanide vats extended for miles down-gradient from the mills, filling entire valleys (MHS, 1974).



CDM

Figure 2-1
Site Location Map

Three cyanide mills were in operation in the district between 1900 and 1941 as follows:

- Kendall Mill (1900-1912)
- Barnes-King Mill (1901-1923)
- North Moccasin Syndicate Mill (1936-41)

2.2 Modern Mining

Modern heap leach operations were initiated by Triad Resources in 1984 and continued by Greyhall Resources through 1986. CR Kendall Corporation took over the operations in 1986 and continued through 1997. The gold recovery process involved agglomeration, cyanide heap leaching, Merrill-Crowe precipitation, carbon recovery and smelting. The operations resulted in the disruption of approximately 460 acres of land. Site features include two heap-leach pads (LP#3 and LP#4), process water ponds, six pits (Horshoe, North Muleshoe, Muleshoe, Haul Road, Kendall and Barnes-King) and three waste rock repositories (Horseshoe, Muleshoe and Kendall).

The impact of the historical and modern mining/milling activities on each of the drainages and the potential interaction between the wastes and high quality or treated water will be evaluated in the following section.

Section 3
Potential Off-Site Sources

The magnitude of any off-site sources within each drainage was evaluated and used to predict the impact of the sources on high quality or treated water introduced into that drainage. The magnitude of any off-site sources was evaluated based on the following:

- Historical information relating to the mining/milling activities affecting each drainage (journal articles, maps, production figures, photographs, etc.).
- Historical air photos showing the mining/milling wastes.
- Laboratory analyses of off-site sediments or wastes (if present).
- Laboratory analyses of on-site and off-site surface waters and groundwaters.

In addition, any activities which resulted in a disturbance or re-distribution of the off-site wastes (i.e. use of wastes for construction materials, dams etc.) were evaluated.

3.1 Mason Canyon

3.1.1 Mining/Milling Operations

<u>Kendall Mill</u>

The Kendall Mill was the first mill in the district, beginning operations in November 1900. The mill and the associated Kendall Mine, located 500 feet to the southwest, were started by Harry Kendall. The initial mill had a capacity of 50 tons of ore per day and was located in Mason Gulch about a mile west of the town of Kendall, which sprang up in response to the mining boom in the district. Ore from the nearby Santiago Mine was shipped to the Kendall Mill for processing via an electric tramway.

In May 1901 Harry Kendall sold all of his holdings to Finch and Campbell, who reorganized the company as the Kendall Mining Company. A 500 ton per day mill was constructed by the company on the same spot as the old mill, which was completed April 30, 1902.

In order to meet the water needs of the new 500 ton/day mill, water was obtained from Warm Springs Creek about 4 miles south of Kendall. Warms Springs flowed at a rate of 50,000 gpm and provided the source of water for Warm Springs Creek. Finch and Campbell built a 2 mile long ditch along Warm Springs Creek to convey a portion of the flow to a stone power house. The flowing water turned a 200-horsepower turbine which generated electricity for the mill. A 150-horsepower water pump forced water through a 4-inch cast iron pipe to the Kendall Mill's water tank, 1,250 feet higher in elevation. The main uses of the water were for mixing leaching solution and rinsing tailings from the leaching tanks into Mason Canyon. The water for washing away the tailings was pumped through 2-inch pipes to the roof of the vat house and into each tank.

During the tenure of Harry Kendall, approximately $35,000 in gold (MHS, 1909) was produced from the Kendall Mine from ore averaging $8 to $10 per ton (MHS, 1974), resulting in an approximate tailings production of 3,889 tons.

The 12 vat leaching house of the new mill was located on a very steep hillside (Sanborn, 1902, 1905, and 1908 Figures 3-1 through 3-3), presumably to facilitate more efficient removal of the tailings from the vicinity of the mill site. In later years, tailings were discharged from the vat house by use of a tailings elevator due to the height of the growing tailings pile (see Figure 3-4).

The company operated until 1912 when the mill and mines were sold and leased to small mining concerns. During the period 1901 through 1912, the Kendall Gold Mining Company produced an estimated $3, 741,365 in gold (MHS, 1909). In 1904, the gold value of the ore was estimated to have been about $6.50 per ton (Anonymous, 1904), therefore, the volume of tailings produced was about 575,595 tons.

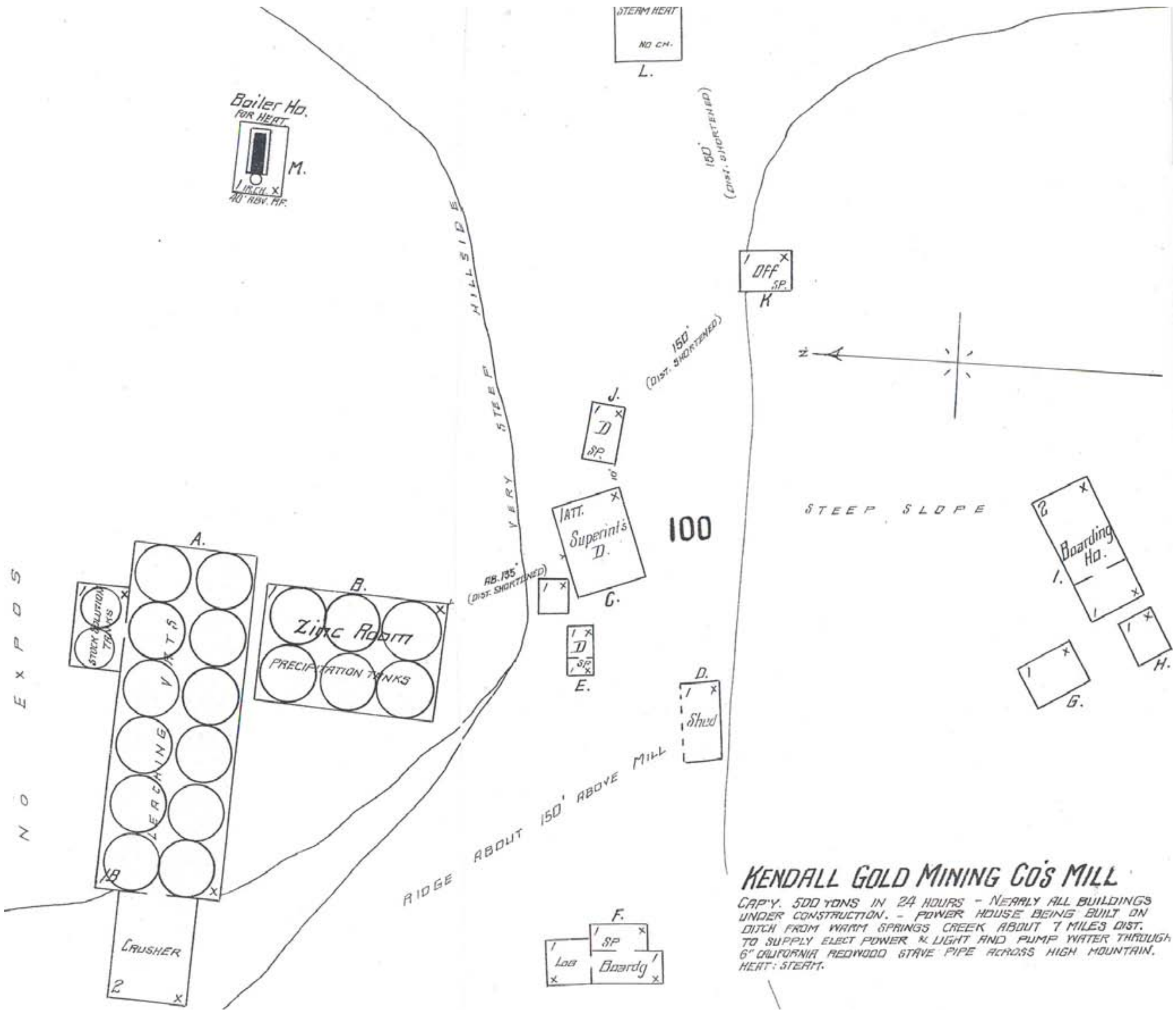
In the final years of mill operation (owners; Kendall Mine Lease, Kendall Leasing Company and E.G.R. Manwaring) gold production was only $138,183. Assuming an average ore grade of $3 per ton (Blixt, 1933) results in a tailings production of 46,061 tons. The total volume of tailings washed into Mason Canyon from 1900 through the end of operations is estimated to total 625,545 tons. The calculated tailings mass compares reasonably well with the estimate of 700,000 tons provided by Blixt (1933). The light colored tailings in Mason Canyon are clearly shown on all of the air photos (see Figures 3-5 through 3-7) and in the historical photo (Figure 3-4).

Modern Mining

The process ponds, process plant, and leach pads of the modern mining activities are all located in Mason Canyon, which is consequently referred to as the process valley. The early CR Kendall operations can be seen in the air photo (May 21, 1988) shown in Figure 3-6. The operation shown in the photo consists of a single heap leach pad, and one, possibly two pits. The operation was later expanded to include two larger leach pads (LP#3 and LP#4) and the addition of the Kendall Pit at the head of Mason Canyon (see Figure 3-7).

Waste Disturbance

The facilities within the process valley were built directly into the historical tailings deposits, as is evident in Figures 3-6 and 3-7. In addition, historical tailings were used to construct the underliners and overliners for the new leach pads. A summary of the volumes used is provided in Table 3.1-1 (Glen Pegg Memo dated October 6, 2003).



CDM

Figure 3-1
1902 Sanborn Map, Kendall Mill

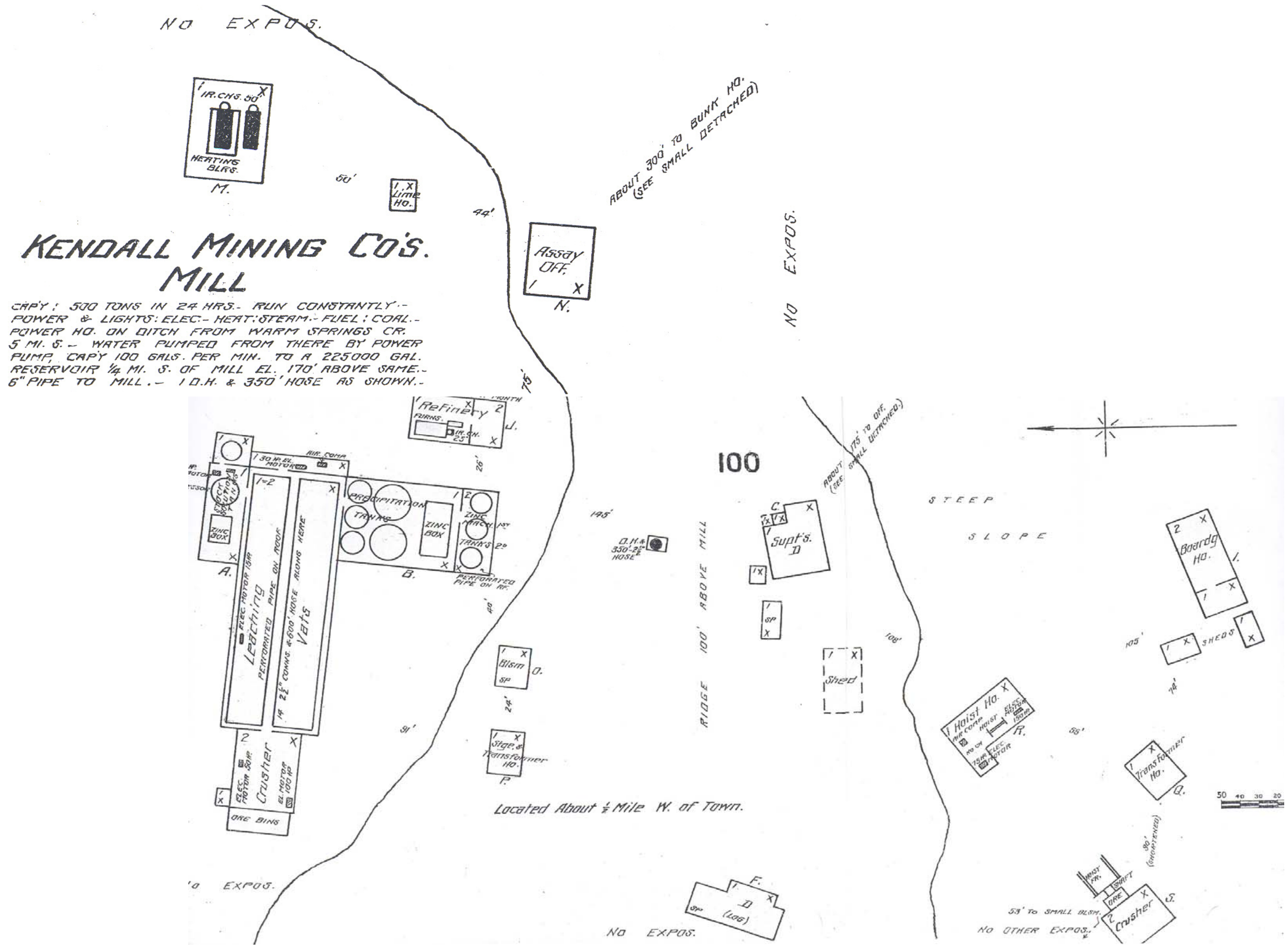


Figure 3-2
1905 Sanborn Map, Kendall Mill and Mine

CDM

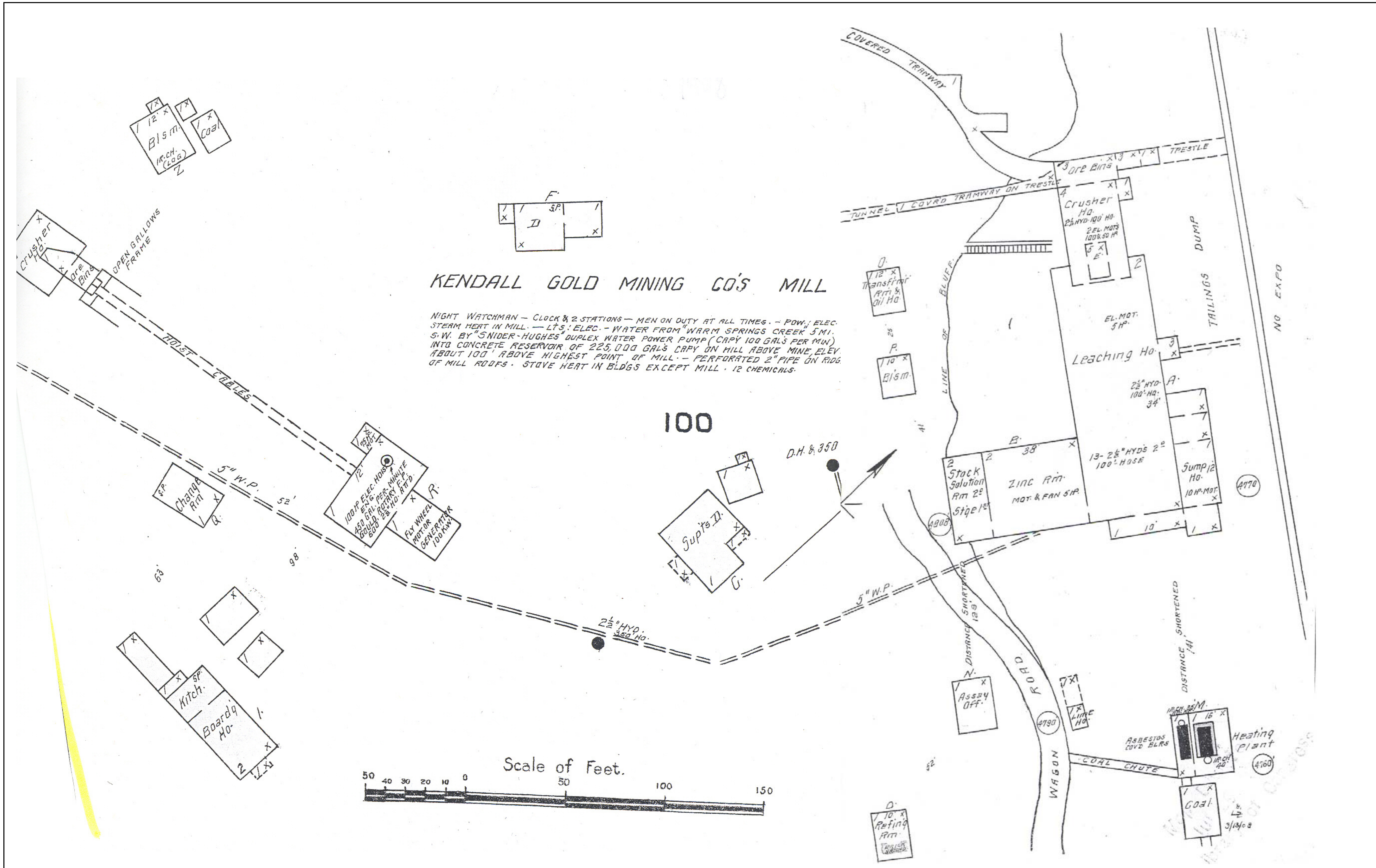
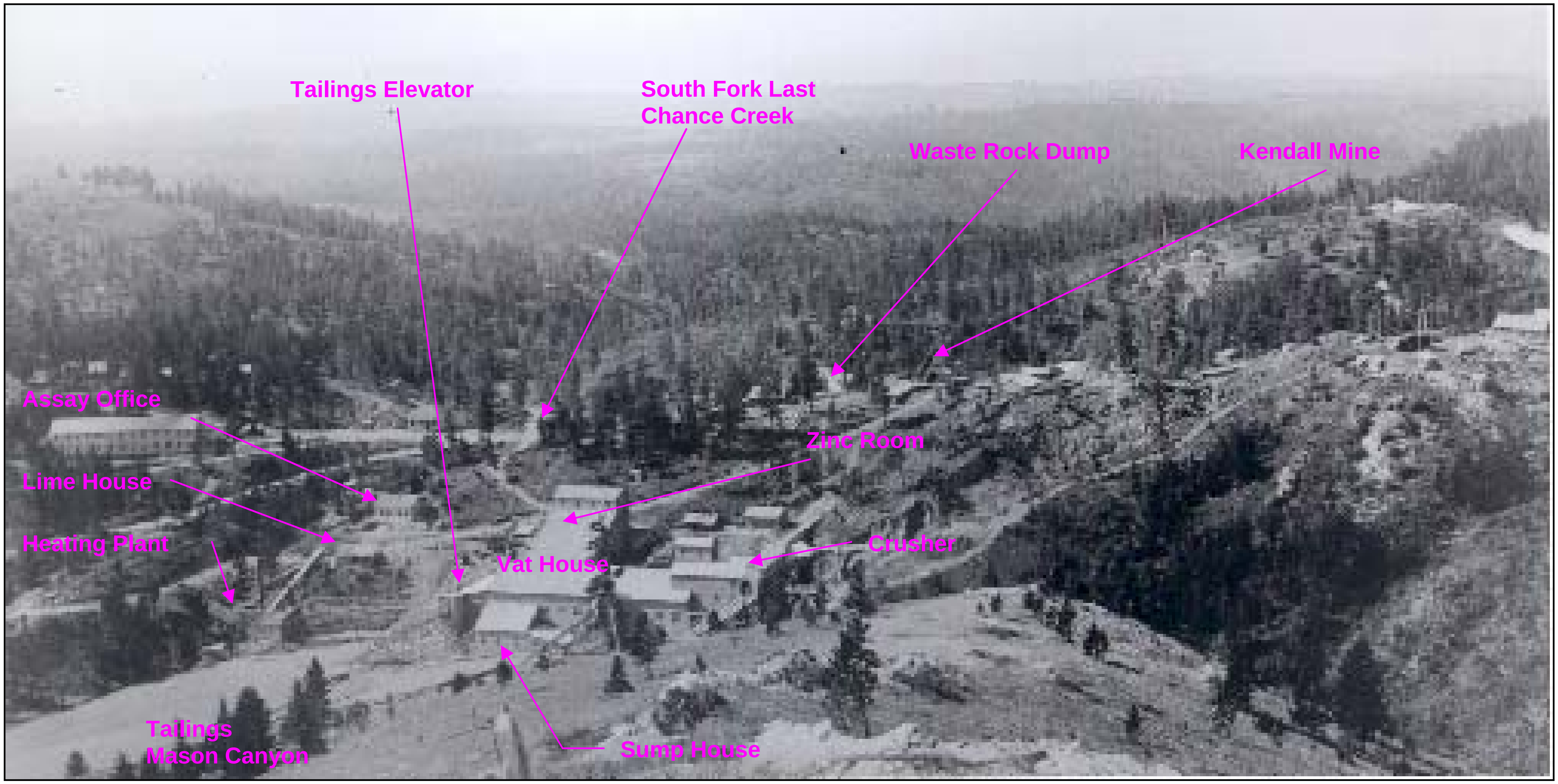


Figure 3-3
1908 Sanborn Map, Kendall Mine and Mill



CDM

Figure 3-4
View of the Kendall Mill and Mine Looking Southwest (Circa. 1909). Note the Tailings in the Left Foreground and the Waste Rock in the Center Background. (Photo by G.C. Morton, Courtesy of Montana Historical Society)

Figure 3-5
Photograph of the CR Kendall Mine site and vicinity 5-23-1938

CDM

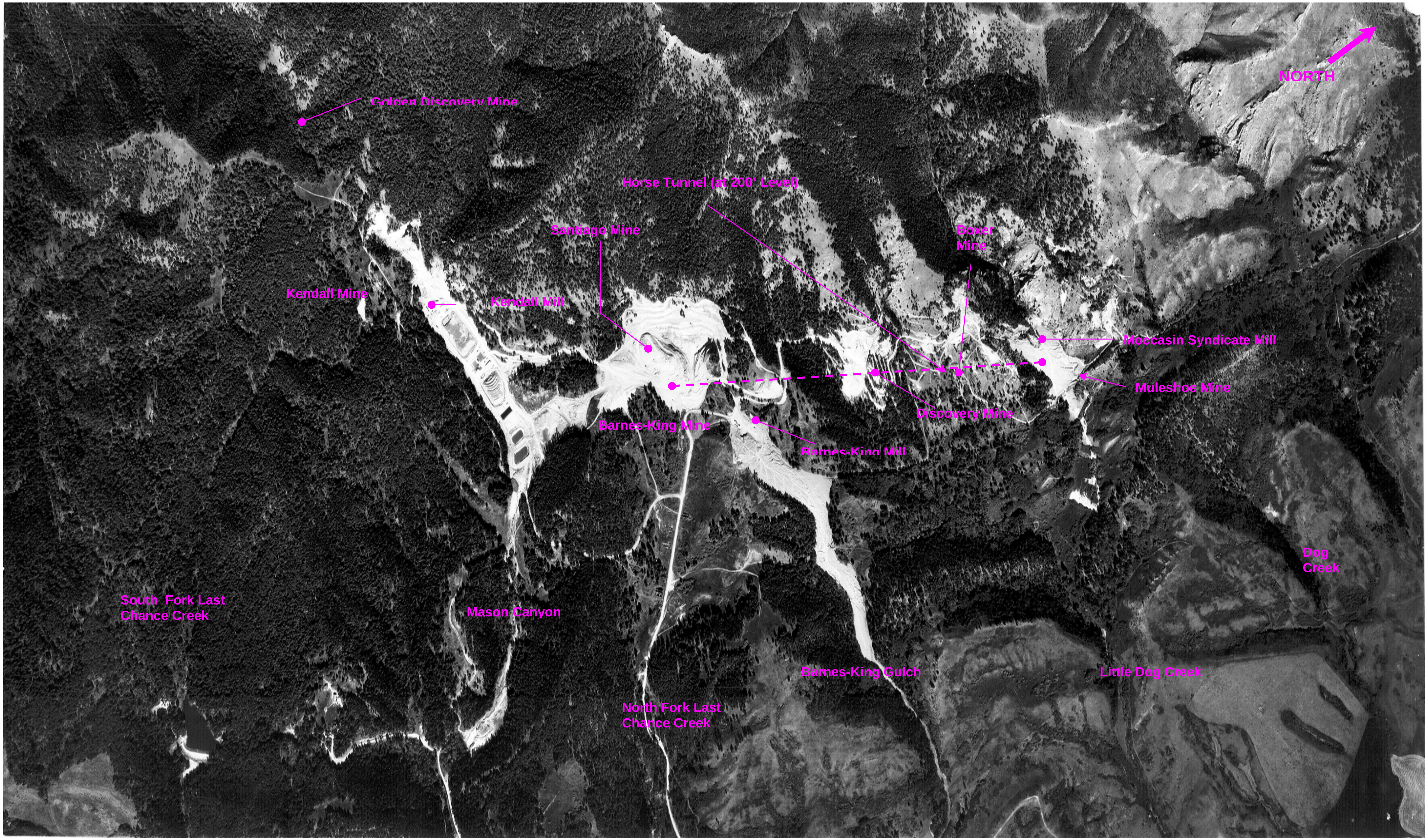
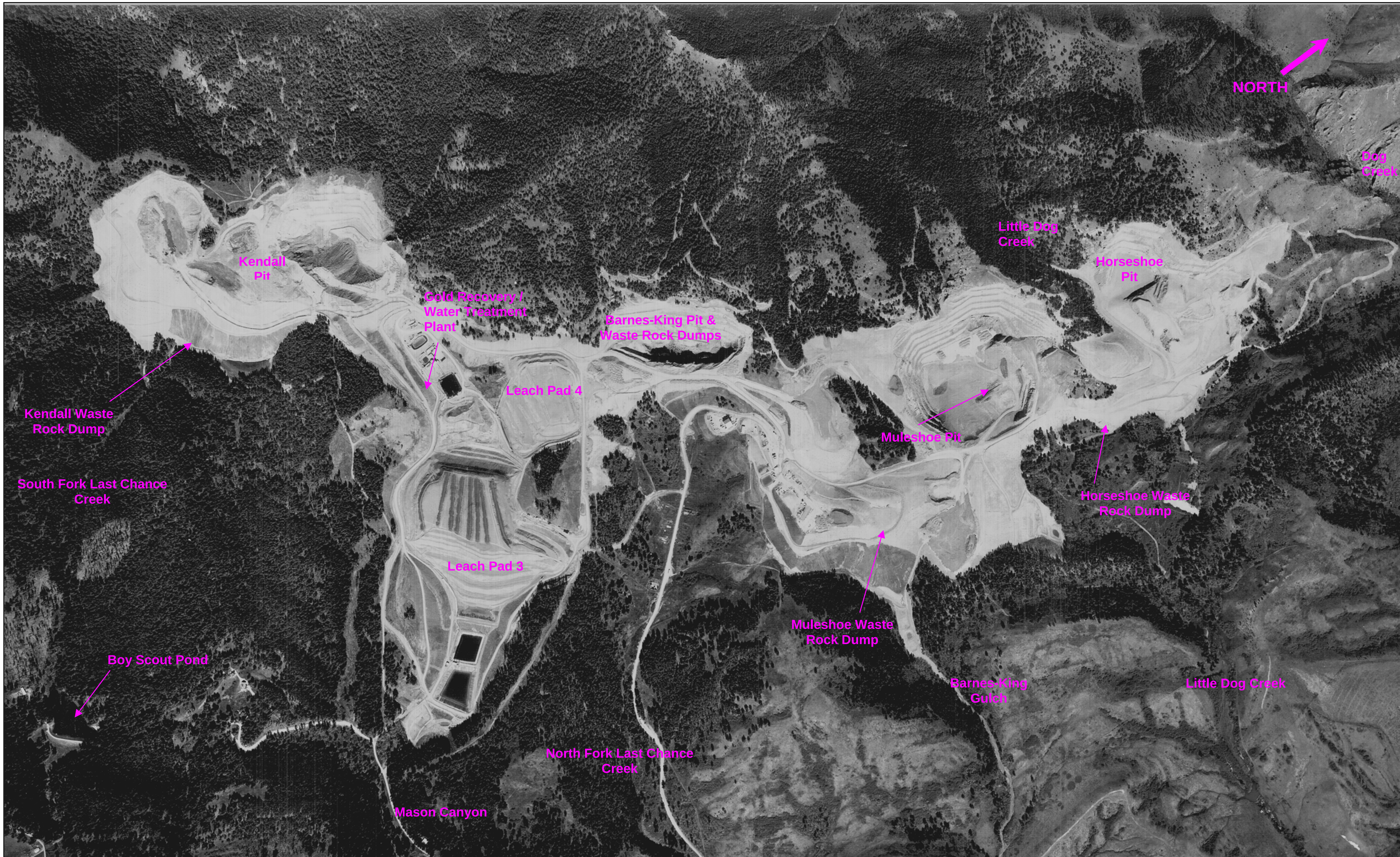


Figure 3-6
Photograph of the CR Kendall Mine Site and Vicinity 5-22-1988

CDM



CDM

Figure 3-7
CR Kendall Mine Layout
Circa. 1997

Table 3.1-1
Summary of Historical Tailings Use

Facility	Area (acres)	Underliner depth (in)	Underliner Volume (yds)	Overliner Depth (in)	Overliner Volume (yds)	Origin
Pad 3	14.2	12	22,900	18	34,400	Barnes-King tailings
Pad 4	26.5	8-12	35,600			Kendall tailings
	8.4	8-12	11,300	18	9,000	N. Moccasin Syndicate tailings[1]

[1] Also referred to as the Horseshoe Tailings

The construction of the underliner for pad 3 was apparently underway in May of 1988, as excavations within the Barnes-King tailings are evident in the 1988 air photo (Figure 3-6). The underliner for pad 4 was constructed using historical tailings with 2% (by weight) of bentonite added to reduce the permeability. Crushed ore from the Muleshoe Pit was used to construct the overliner.

3.1.2 Sediment Quality

No sediment data has been collected in Mason Canyon as far as is known.

3.1.3 Water Quality

The logs for two of the wells in Mason Canyon (TMW-14 and TMW-18) indicate the presence of historical tailings. Although the wells were not necessarily screened within tailings, the water quality in the well may be influenced by the overlying tailings. The water quality in these two wells is very similar as shown in Table 3.1-2.

Table 3.1-2
Water Analyses for Wells TMW-14 and TMW-18
Mason Canyon Drainage

Parameter[1]	WQB-7 Criteria[2]	TMW-14	TMW-18
		Range[3]	**Range[3]**
SC (μmho/cm)	---	658-1000	787-990
Sulfate	---	31-97	22.3-102
Nitrate/nitrite as N	10	<0.05-1.34	0.3-1.83
Arsenic	0.020	<0.005	<0.005
Iron	---	<0.03-0.65	<0.003-0.12
Selenium	0.050	<0.005-0.004	<0.005-0.003
Thallium	0.002	<0.002-**0.007**	<0.002-**0.04**
Zinc	2.0	<0.01 – 1.1	<0.01-0.14

[1] Units are mg/kg unless otherwise noted (metals are dissolved concentrations).

[2] Human Health criteria for groundwater.

[3] Data from July 1989 to July 2001.

Bold indicates value above the WQB-7 criteria (human health groundwater).

The tailings impacted groundwaters are low in sulfate relative to the waste rock impacted waters found in some of the other drainages due to the fact that much of the historical mining was performed within the rich oxide ore. When sulfide ore was encountered it was roasted to drive off the sulfides as sulfur dioxide gas. Any sulfides present in the waste rock would have remained intact and would be available for oxidation to sulfate. The relatively high nitrate/nitrite in the waste rock leachate (for example in the pump-back wells) compared to the historical tailings may be related to the differences in the types of explosives used.

The water quality in the Mason canyon drainage is monitored at station KVSW-4. Water quality data from 1984 through 2001 are presented in Table 3.1-3.

Table 3.1-3
Water Analyses for Surface Water Station KVSW-4
Mason Canyon Drainage

Parameter[1]	**WQB-7 Criteria**[2]	**Range**[3]
SC (μmho/cm)	---	93-1320
Sulfate	---	12-323
Nitrate/nitrite as N	10	<0.05-5.45
Arsenic	0.018	<0.005-**0.398**
Iron	---	<0.03-15.7
Selenium	0.005	<0.005-**0.01**
Thallium	0.0017	<0.002-**0.149**
Zinc	0.388 @ >400 mg/L hardness	<0.01-**1.66**

[1] Units are mg/kg unless otherwise noted (metals are dissolved concentrations).
[2] The lowest value between the human health surface water and chronic aquatic standards.
[3] Data from April 1984 to July 2001.
Note: Bold indicates value above the WQB-7 criteria (human health or aquatic).

The surface water data from the 1980s generally reflect the low sulfate, low selenium signature of the historical tailings, however, the nitrate is higher than would be expected for a tailings impacted water. The later data show higher sulfate and selenium results due to the influence of the modern mining activities. The thallium could have been derived from either the historical tailings, the modern mining activities or both. The nitrate/nitrite may be associated with LAD or modern mining wastes within Mason Canyon.

3.1.4 Conclusion

A high quality or treated water introduced into Mason Canyon would likely be adversely affected (especially with respect to thallium) from sediments impacted by historical and modern mining operations. The vast majority of the Kendall tailings are located within the permit boundary of the CR Kendall mine, so if a high quality water is discharged down-gradient of the mine boundary, most of the historical tailings would be avoided. However, the sediments within the drainage which have been impacted by waters with elevated thallium (up to 0.149 in KVSW-4), arsenic (up to

0.398 in KVSW-4) and zinc (up to 1.66 mg/L in KVSW-4) would likely represent a secondary source which could adversely affect a high quality water.

3.2 South Fork Last Chance Creek

3.2.1 Mining/Milling Operations

Kendall Mine

The air photos and mill photo show an area of light colored material down-gradient of the Kendall Mine at the head of the S. Fork of Last Chance Creek. The material was probably waste rock, as the Sanborn maps (Figures 3-1 through 3-3) of the Kendall Mill and mine show a crusher house and an ore bin at the Kendall adit. Therefore, the mined material was probably crushed and the ore sorted from the waste rock at the head of the S. Fork. The resulting waste rock dump may have impacted the water quality in the S. Fork drainage or contributed fine-grained mine waste to the drainage and/or to the Boy Scout Pond. CR Kendall contends that the source of the arsenic exceedances within the pond water are the result of high arsenic concentrations in the background soils in the S. Fork drainage (WMC, 2003). While arsenic may be leaching from background soils, the presence of fine-grained waste rock within the pond can not be ruled out, and the relative contribution from each source is unknown.

Modern Mining

The Kendall Pit was excavated at the head of Mason Canyon beginning in 1991. The waste rock derived from the Kendall Pit was placed in two repositories at the head of the S. Fork of Last Chance Creek. As shown in figures 3-5 and 3-6, Mason Canyon and the S. Fork of Last Chance Creek were once separated by a low divide, which was later excavated when the Kendall pit was mined (see Figure 3-7). The East Kendall waste rock dump was loaded between 1991 and 1993, while the West Kendall was loaded between 1992 and 1993 (WMC, 1999). These facilities were apparently placed on top of the historical waste rock dump from the Kendall Mine.

Waste rock reclamation activities occurred concurrently with and following loading. Sediment traps were constructed within the east and west forks of the drainage in 1994 and 1995-96, respectively (WMC, 1999). As of 1996, the groundwater beneath the waste rock has been collected at pump-back station KVPB-5.

Waste Disturbance

As far as is known, the historical waste rock was not removed or used for construction purposes. The Boy Scout Pond was constructed in about 1982, presumably out of non-waste materials. The fine fraction of the historical waste rock pile (1982-1990) or the Kendall waste rock dump (1991-1993) may have washed down the S. Fork and settled in the Boy Scout pond.

3.2.2 Sediment Quality

Sediments were collected within the Boy Scout pond, the Lewis Harrel Pond and the Jack Ruckman Pond by CDM in July 2003. The results (presented in Appendix B) show that the concentrations of selenium and thallium were nondetect (<1 mg/kg) while arsenic concentrations were low (2-3 mg/kg). The ponds sampled, especially the Harrel and Ruckman ponds, are well down the drainage and probably do not contain significant sediments from the modern or historical mining activities. However, because of elevated arsenic concentrations observed in the water it is possible that the Boy Scout pond contains waste rock material either at depth or in an area of the pond not sampled.

3.2.3 Water Quality

The surface water and groundwater in the S. Fork drainage is influenced by the Kendall waste rock dump. Surface water analytical data for station KVSW-5 collected by CR Kendall (2002) is presented in Table 3.2-1.

Table 3.2-1
Surface Water Analyses – Station KVSW-5

Parameter[1]	**WQB-7 Criteria[2]**	**Range[3]**
SC (μmho/cm)	---	1000-2250
Sulfate	---	414-1240
Nitrate/nitrite as N	10	2.26-6.05
Arsenic	0.018	<0.005-0.011
Iron	---	<0.03-0.12
Selenium	0.005	<0.005-0.004
Thallium	0.0017	<0.1-**0.041**
Zinc	0.388 @ >400 mg/L hardness	<0.01-0.14

[1] *Units are mg/L unless otherwise noted (metals are dissolved).*
[2] *The lowest value between the human health surface water and chronic aquatic standards.*
[3] *Data from May 1994 to November 2001.*
Note: Bold indicates value above the WQB-7 criteria (human health or aquatic).

Pump-back station (KVPB-5) was installed to capture the waste rock leachate, but has been only partially effective (Gallagher, 2002). The relatively high sulfate and thallium level above the WQB-7 criteria for the post pump-back sample shown in Table 3.2-1 support the conclusion of Gallagher (2002), but may also be due to desorption reactions of sulfate and thallium from impacted sediments within the drainage.

The low arsenic concentration in KVSW-5 is puzzling, given the frequent arsenic concentrations above the WQB-7 criteria within the Boy Scout pond water, including the latest result collected by CDM in July 2003 (0.021 mg/L). The sediment within the Boy Scout pond may attain reducing conditions at depth, which could dissolve arsenic-bearing iron oxyhydroxide solids derived from the historical or modern waste rock dumps. Under oxidizing conditions, such as would exist in a surface sediment, iron oxyhydroxides are stable, while under reducing conditions, such as in organic rich muds the solids tend to dissolve, releasing any arsenic contained within the material.

The pond water analyses for the Harrel and Ruckman ponds are all within WQB-7 human health surface water and aquatic standards.

3.2.4 Conclusion

The introduction of a high quality or treated water into the S. Fork would likely result in desorption of thallium and possibly other parameters from the impacted sediments within the drainage into the water.

3.3 North Fork Last Chance Creek

3.3.1 Mining/Milling Operations

No historical mining activities in N. Fork Last Chance Creek were reported in the literature or were evident on the air photos. Goldfields Inc. encountered what they described as "hot soils" during exploration activities at the head of the N. Fork, which they attributed to historical activities such as an assay office (Glen Pegg personal communication 10-13-03). WMC (1999) reported that a small open pit and associated waste rock dump were present at the head of the drainage in 1987. These modern mining features were likely part of the Triad/Greyhall operations.

3.3.2 Sediment Quality

No sediment data have been collected within the N. Fork drainage as far as is known.

3.3.3 Water Quality

Due to the limited mining impacts on the N. Fork drainage, the best prediction of surface water quality in the future will be the past surface water quality. Surface water station KVSW-3 was monitored from 1982 until 1999 when the surface flow dried up. The latest analysis is shown in Table 3.3-1.

Table 3.3-1
Analyses at Surface Water Location KVSW-3 in N. Fork Collected May 25, 1999

Parameter[1]	**WQB-7 Criteria**[2]	**Range**[3]
SC (μmho/cm)	---	757-1040
Sulfate	---	110-252
Nitrate/nitrite as N	10	<0.05-4.29
Arsenic	0.018	<0.005-**0.19**
Iron	---	<0.03-0.24
Selenium	0.005	<0.005-**0.01**
Thallium	0.0017	<0.002-**0.008**
Zinc	0.388 @ >400 mg/L hardness	<0.01-0.09

[1] Units are mg/L unless otherwise noted (metals are dissolved).
[2] The lowest value between the human health surface water and chronic aquatic standards.
[3] Data from May 1982 to May 1999.
Note: Bold values indicate the WQB-7 criteria is exceeded (human health or aquatic).

The slightly elevated thallium and selenium levels may represent background conditions or may be a result of the limited mining activities at the head of the drainage (small waste rock pile and pit in 1987). The background data collected by WMC (1999) suggest that these levels are well within the area background concentrations.

3.3.4 Conclusion

The addition of a high quality or treated water to the N. Fork drainage would likely result in selenium and thallium levels above the WQB-7 criteria due to possible historical and/or modern mining impacts to the sediments within the drainage.

3.4 Barnes-King Creek

3.4.1 Mining/Milling Operations

Barnes-King Mill

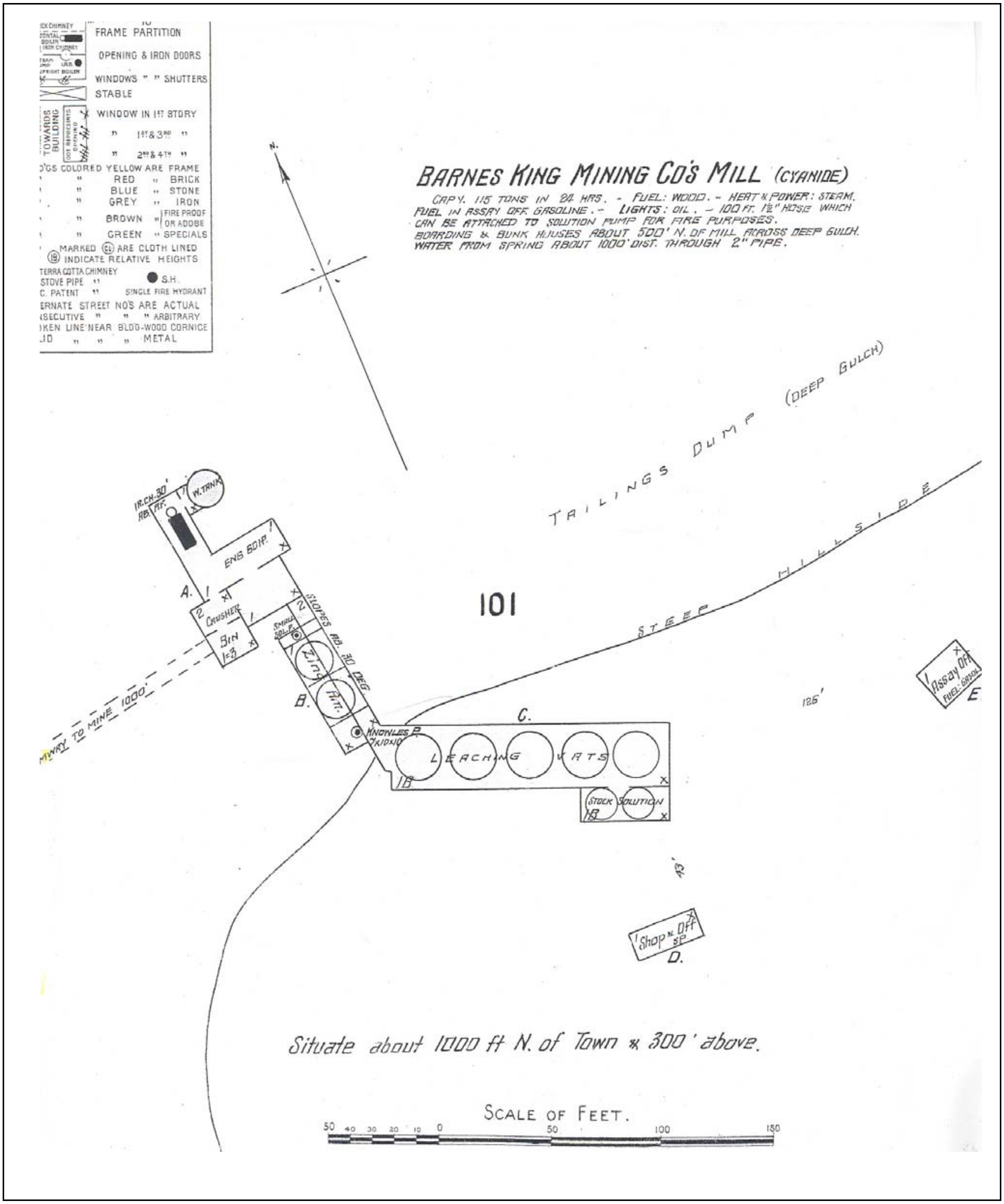
About a mile to the northeast of the Kendall properties, the Barnes-King group of claims was explored via an open cut and found to be suitable for cyanide milling. The Barnes-King mines consisted of 15 claims, including the Horseshoe group, Muleshoe, Passaic and Discovery claims. A 100 ton/day cyanide mill was completed by the fall of 1901 within the confines of the Passaic claim located in the Barnes-King drainage.

Ore from the northern mines was trammed through the Horse Tunnel, which was a 3,700 foot tunnel opened from the 200 foot level of the Barnes-King Mine, connecting the workings of the Barnes-King with those of the Discovery, Boxer, and Muleshoe mines and terminating at the mouth of Little Dog Creek (see Figure 3-5).

Between 1902 and 1905, the mill was expanded from a 5 vat to a 10 vat operation, but apparently the addition did not result in an increased milling capacity. Both the 5 vat mill shown on the 1902 Sanborn Map and the 10 vat mill shown on the 1905 Sanborn map have a listed capacity of 115 tons/day (see Figures 3-8 and 3-9).

In 1906, the original owners of the Barnes-King properties sold out to a group of New York and Butte capitalists who organized the holding as the Barnes-King Development Company. The new group developed the North End Mine north of Dog Creek. The ore was hauled from this mine by horse drawn trains over a trestle, which spanned Dog Creek, to the head of the Horse Tunnel in Little Dog Creek where the ore was trammed to the Barnes-King Mill via the Horse Tunnel.

The new company also expanded the capacity of the cyanide mill from 115 tons/day to a reported 500 tons/day (MHS, 1974). The increased capacity was apparently achieved by enlarging the crusher house (Figure 3-10). In 1912, the Barnes-King Development Company purchased the Santiago Mine and again expanded the capacity of the mill to accommodate the additional ore. In 1915, the company purchased all of the property of the Kendall Mining Company. By 1920, most of the ore grading better than $3/ton was consumed and the company was forced to shut down operations, and by December 1925 the Barnes-King Development Company was dissolved.



CDM

Figure 3-8
1902 Sanborn, Barnes-King Mill

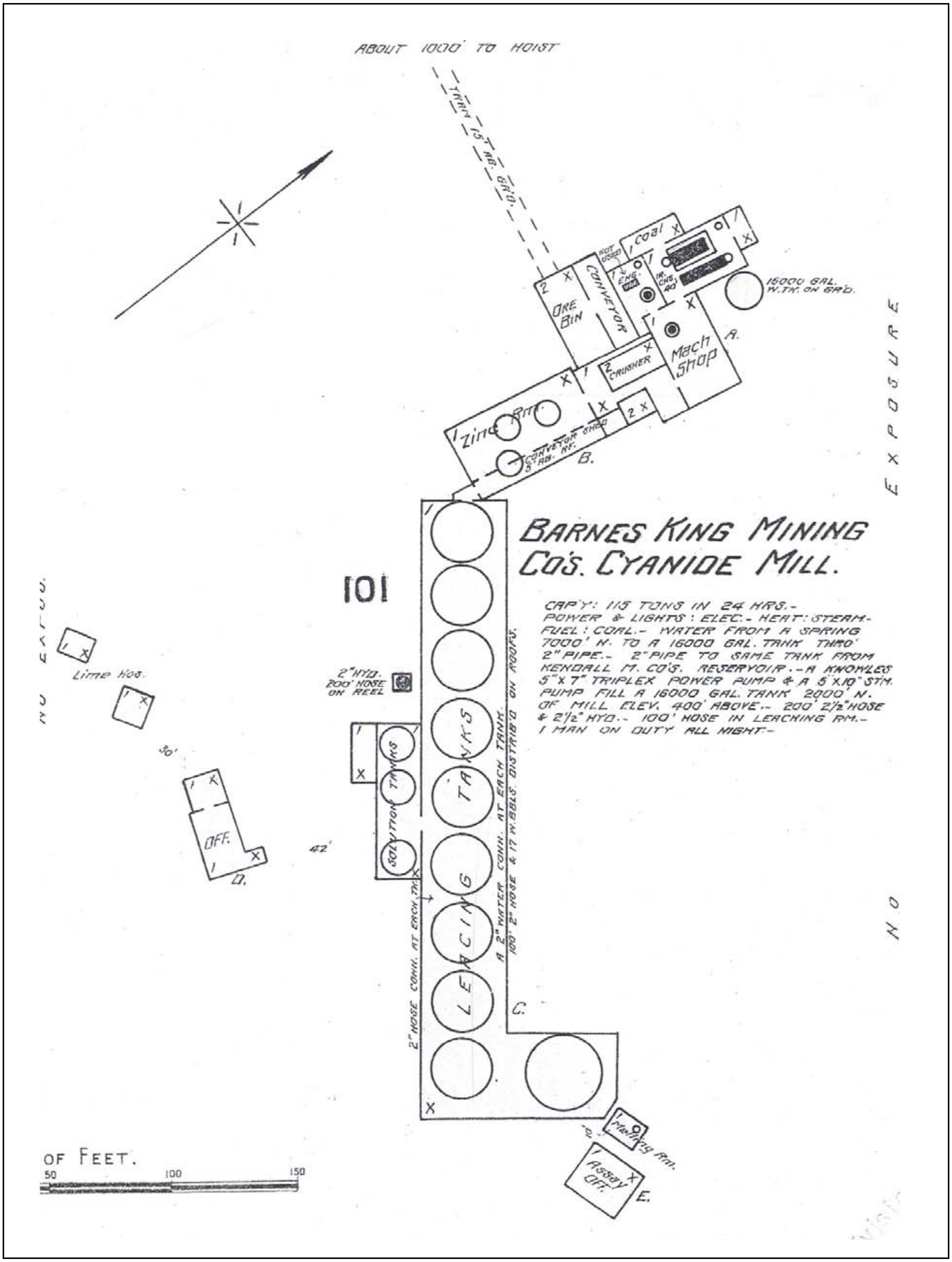


Figure 3-9
1905 Sanborn Map, Barnes-King Mill

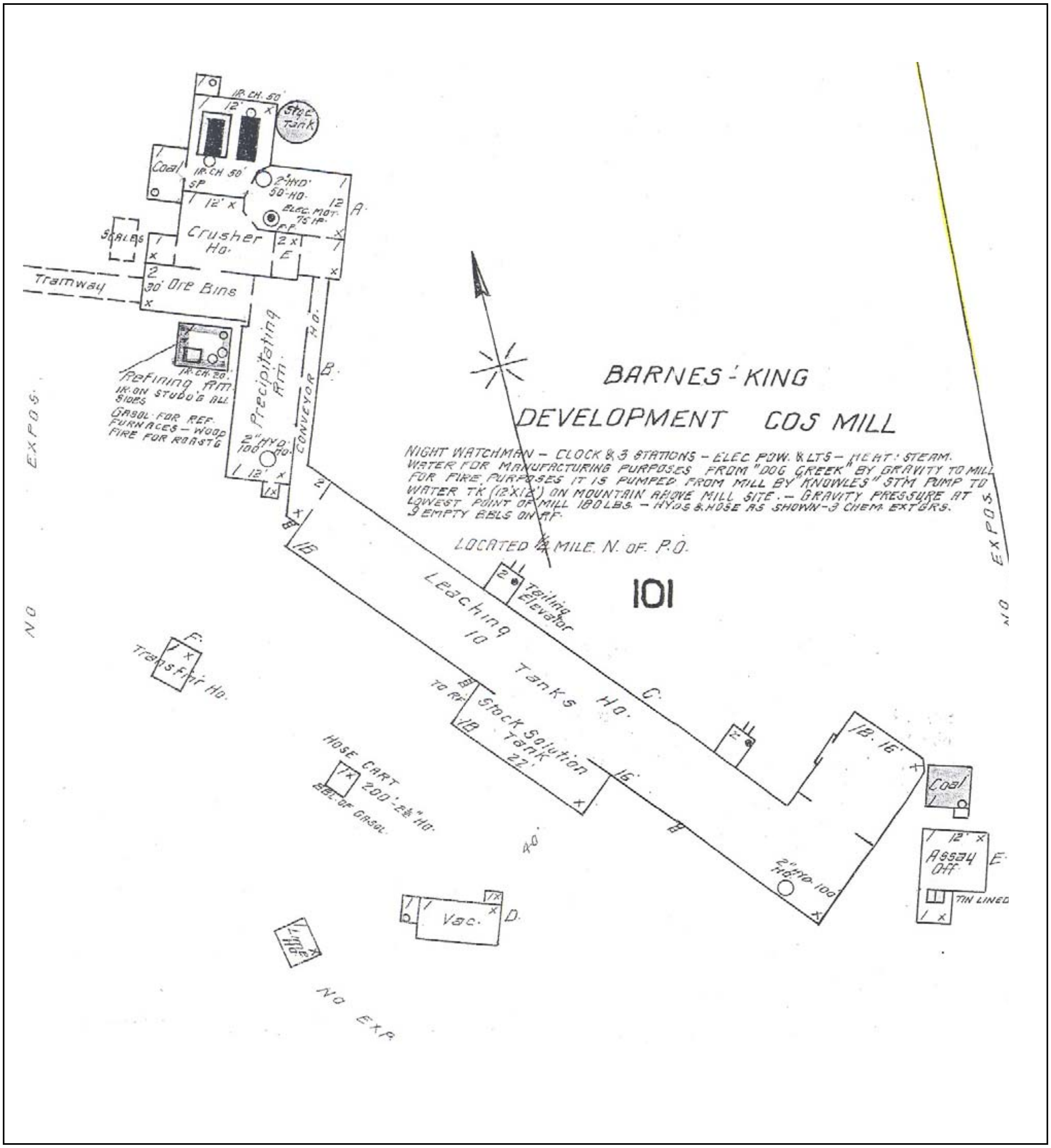


Figure 3-10
1908 Sanborn Map, Barnes-King Mill

The Barnes-King Mill operated in much the same way as that described for the Kendall Mill, with the spent ore from the vats being washed into the Barnes-King Gulch. The 1905 Sanborn map (Figure 3-9) has a notation indicating that the water supply for the mill was derived from two sources; the Kendall Mill Reservoir and a spring located 7000 feet to the north. The 2-inch water line connecting the Barnes-King water tank with the Kendall Mill power house was completed in 1905 (MHS, 1974). The "Kendall M. Cos. Reservoir" indicated on the 1905 Sanborn probably refers to the facilities located at the powerhouse on Warm Springs Creek. The 1908 Sanborn map (Figure 3-10) indicates that the spring water was derived from Dog Creek, which is about 7,000 feet north of the mill. Figure 3-11, shows the 10 vat Barnes-King Mill (circa 1909-1910) looking south by southwest. The photo shows a large volume of tailings which had accumulated outside of the vat building. Two tailings elevators are evident in the photograph. A gully is visible by each elevator where the tailings were washed onto the top of the pile.

A circa 1909 photo of the Barnes-King mine and the back side of the mill is shown in Figure 3-12 (looking east). The photo shows the tram system used by the company and a developing waste rock pile adjacent to the adit. The B-K adit was located about where the Barnes-King pit was later excavated.

Based on a gold production figure of $4,625,313 (MHS, 1909) and an estimated ore grade of $9/ton results in a tailings production of roughly 513,924 tons. The estimate can probably be considered a minimum, as the ore grade more than likely decreased between 1904 and the closing of the mill in 1920. The large volume of tailings within Barnes-King gulch is evident in all of the historical air photos. The large-scale tailings deposition extends approximately half a mile down the gulch, while smaller deposits can be seen for nearly a mile down-gradient (Figures 3-5 through 3-7).

Modern Operations

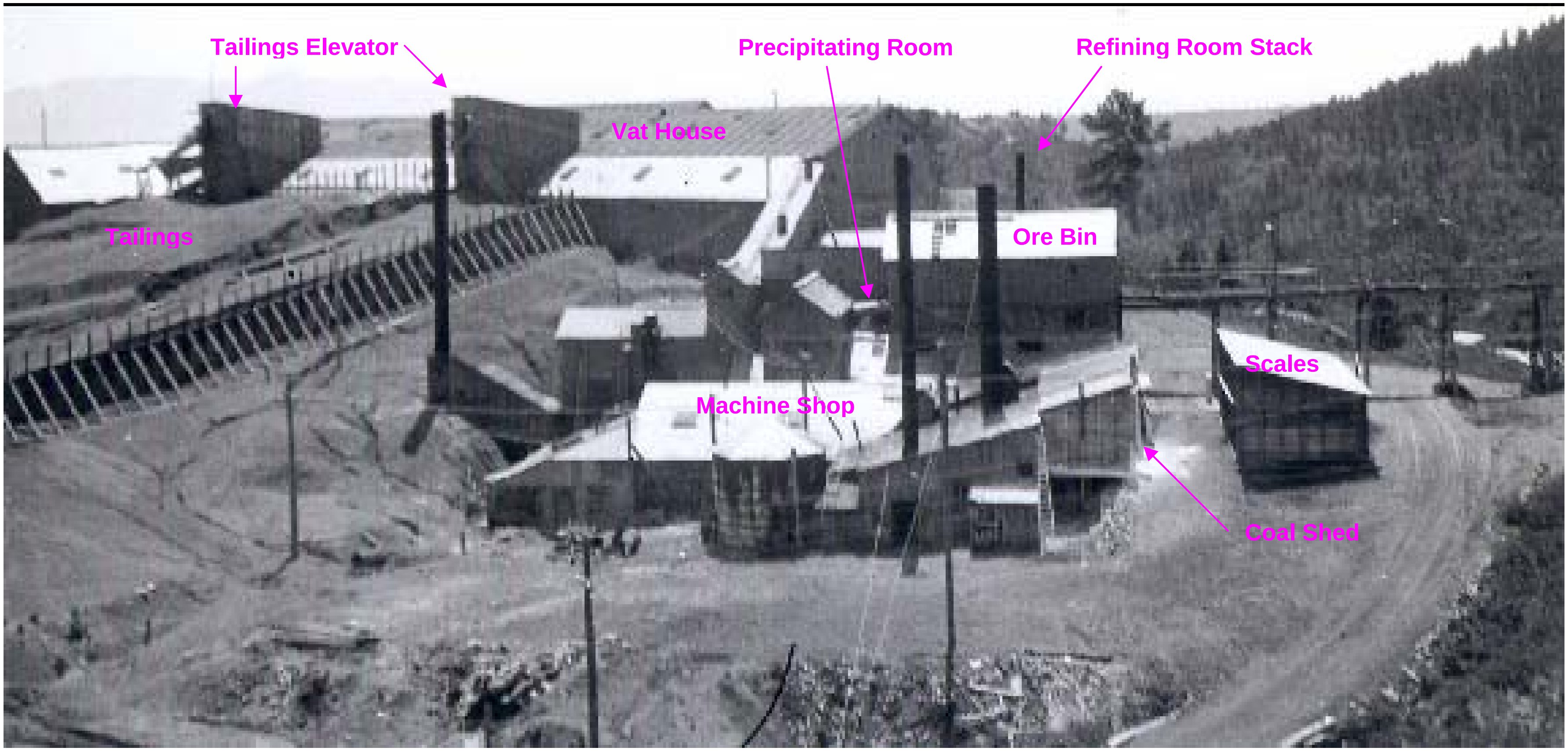
The Muleshoe pit was excavated between 1988 and 1991. The Muleshoe waste rock dump at the head of Barnes-King Gulch was loaded during the same time period. A portion of the dump was loaded onto historic tailings (Gallagher, 2002).

Groundwater from beneath the Muleshoe Dump is collected at pump-back station KVPB-2 just down-gradient from the toe of the reclaimed dump. Operation of the pump-back well began in 1996 and has been operated at a rate of between 3.4 to 6.5 gpm to the present time.

Waste Disturbance

WMC (1999) reported that some of the Barnes-King tailings were removed in 1988 from the upper part of the drainage. WMC is likely referring to the 57,300 yards of B-K tailings used during construction of leach pad 3 in Mason Canyon (see Table 3.1-1).

Additional historical tailings were removed by CR Kendall from between the toe of the Muleshoe dump and the permit boundary in 1996-97.



CDM

Figure 3-11
View of the Barnes-King Mill (Circa 1909-1910) Looking South-Southwest.
Note the Large Volume of Tailings Outside of the Vat House.
(Photo by G.C. Morton, Courtesy of Montana Historical Society)

CDM

Figure 3-12
The Barnes - King Mine and Mill Looking East (Photo by G.C. Morton, Courtesy Montana Historical Society

3.4.2 Sediment Quality

No Barnes-King sediment analyses could be located. Tailings samples and overburden were analyzed for a limited list of parameters (no thallium, selenium or arsenic) in 1984 as shown in Table 3.4-1.

Table 3.4-1
Tailings and Overburden Analytical Results

Parameter	Barnes-King Tailings	Barnes-King Overburden
Cadmium	<0.1	<0.1
Copper	0.3	0.2
Iron	8	6
Lead	14.5	3.8
Manganese	3.7	2.3
Nickel	0.1	0.1
Zinc	34.4	2.2
Aluminum (water Soluble)	0.6	0.3

All units are in mg/kg

Although some of the most important parameters were not analyzed, the results indicate that the tailing are significantly higher than the overburden in terms of lead and zinc. However, even the tailings concentrations are low in the parameters analyzed compared to other tailings samples from other mining sites.

3.4.3 Water Quality

No known groundwater wells have been completed into historical tailings which have not been impacted by seepage from the Muleshoe waste rock dump. In general, CR Kendall's monitoring network is focused on the mine permit area, while private off-site water supply wells are generally not completed within the historic tailings. However, analyses from two springs which are believed to have been sourced within or beneath the historic tailings are available. The first, the Peters Spring, has been regularly monitored from September 1989 through May 2000 when it went dry (Mr Peters subsequently installed a pipe into the tailings to convey flow to a stock tank). Representative results are shown in Table 3.4-2.

Table 3.4-2
Peters Spring Analytical Results[1]

Parameter	**WQB-7 Criteria[2]**	**Dissolved Concentration (mg/L unless noted otherwise)**		
		9/28/89	**5/16/95**	**5/15/00**
SC (μmho/cm)	---	830	1560	862
Sulfate	---	80	758	279
Nitrate/nitrite as N	10	<0.05	0.94	<0.01
Arsenic	0.018	**0.055**	**0.019**	**0.030**
Iron	---	<0.03	0.06	<0.01
Selenium	0.005	<0.005	<0.005	**0.006**
Thallium	0.0017	-	**0.095**	**0.09**
Zinc	0.388 @ >400 mg/L hardness	0.02	0.06	0.02

[1] Data from CR Kendall (2002).
[2] The lowest value between the human health surface water and chronic aquatic standards.
Note: Bold values indicate the WQB-7 criteria is exceeded (aquatic or human health).

The first analysis from September 1989 appears to be representative of water which has interacted with historic tailings deposits (high arsenic and low sulfate). The Muleshoe waste rock dump had just been begun the previous year and any leachate from the facility had apparently not yet affected the water quality at the Peters Spring approximately a third of a mile down-gradient of the present toe of the dump. The historical tailings leachate apparently had relatively low sulfate and nitrate values or the Peters Spring was partially fed by low sulfate/nitrate waters from a non-tailing source. However, the relatively elevated arsenic value suggests that the Peters Spring was significantly impacted by historic tailings leachate. By 1995, the impact of the Muleshoe waste rock leachate was apparent, with sulfate and nitrate concentrations of 758 mg/L and 0.94 mg/L, respectively. The low initial sulfate concentration for the 1989 sample conflicts with the conclusion of CR Kendall that the elevated sulfate concentrations are due to leaching of natural gypsum-bearing rock in the area.

The final analysis was the last sample taken before the spring went dry. The results are close to the initial non-waste rock impacted analysis, presumably due to the withdrawl of much of the waste rock leachate via the pump-back well. The slow response of sulfate (failure to return to baseline levels after 4 years of pump-back operation) may be due to ion exchange processes between impacted sediments with adsorbed sulfate and the groundwater.

The second spring (really a seep) was at the down stream end of a deposit of historical tailings which had been veneered with a covering of limestone waste rock. The seep was sampled once in September 1996 (see Table 3.4-3). The location no longer exists, as the tailings and waste rock have been removed (WMC, 1999).

Table 3.4-3
BK Tailings Spring 1996 Analysis

Parameter	WQB-7 Criteria[1]	Value (mg/L unless otherwise noted)
pH		7.7
Sulfate	---	790
Nitrate/Nitrite as N	---	2.5
Antimony	0.006	**0.016**
Arsenic	0.018	**0.022**
Iron	---	ND
Manganese	---	ND
Selenium	0.005	**0.01**
Thallium	0.0017	**0.54**
Zinc	0.388 @ >400 mg/L hardness	**NA**

[1] The lowest value between the human health surface water and chronic aquatic standards.

Note: Bold values indicate the WQB-7 criteria is exceeded (aquatic or human health).

ND = Nondetect (the detection limit was not reported).

NA = Not analyzed

The high sulfate and nitrate suggests that the seep has been significantly affected by the waste rock veneer and may not be an appropriate water to predict clean water/historical tailings interactions.

Leaching tests performed by CR Kendall on the B-K tailings (see Table 3.4-4) are consistent with the results from the Peters Spring, in that arsenic and thallium are elevated while sulfate and selenium are low.

Table 3.4-4
Barnes-King Tailings Leachate Analytical Results[1]

Parameter	WQB-7 Criteria[2]	Dissolved Concentration (mg/L unless otherwise noted)	
		3-1 Decant	3-24 Decant
SC (μmho/cm)	---	247	270
Sulfate	---	70	76
Nitrate/nitrite as N	10	0.13	0.12
Arsenic	0.018	**0.054**	**0.063**
Iron	---	0.02	<0.01
Selenium	0.005	0.003	0.003
Thallium	0.0017	**0.208**	**0.259**
Zinc	0.388 @ >400 mg/L hardness	<0.01	<0.01

[1] Data from CR Kendall (1996).
[2] The lowest value between the human health surface water and chronic aquatic standards.
Note: Bold values indicate the WQB-7 criteria is exceeded (aquatic or human health).

The conclusion made by CR Kendall (WMC, 2003) that the elevated selenium concentrations observed in off-site waters are a result of historic tailings is not supported by the leaching data for the Barnes-King tailings. However, it is possible that tailings samples from other drainages or other samples of the B-K tailings could leach selenium.

3.4.4 Conclusion

Based on the available data, it appears as though interaction of a high quality water with the historical tailings could result in release of arsenic and thallium to levels above the WQB-7 criteria. Interaction of a high quality water with (historical or modern mining) impacted sediments could also result in desorption of thallium, arsenic and possibly selenium to levels above the WQB-7 criteria.

3.5 Little Dog Creek

3.5.1 Mining/Milling Operations

North Moccasin Syndicate Mill

In the early 1930's, J.H. McClain purchased nearly all of the claims in the Kendall, Santiago, and Barnes-King groups and formed the North Moccasin Syndicate. In 1936, the company built a 150 ton/day mill at the head of Little Dog Creek, which processed whatever surface ore could be gathered using tractors and bulldozers. The operation was apparently successful, but was forced to shut down at the beginning of World War II as a result of the War Powers Act. The mill later burned down and was never rebuilt.

Although complete production figures are lacking, a conservative estimate of the volume of tailings produced can be obtained by multiplying the daily mill capacity by the number of days the mill was in operation (1016 days, assuming a 6 day work week between September 1936 and closure of the mine in 1941), results in a tailings production of 152,400 tons. A production figure of $278,000 for the period September 1936 through December 1, 1939 (MBMG, 1940) and an estimated ore grade of $2/ton (assumes no ore greater than $3/ton was left by the previous operators) results in a tailings production of 139,000 tons, or approximately 136 tons per day (again assuming a 6 day work week), which compares well with the 150 ton/day estimate above. The tailings from the North Moccasin Mill are shown in all of the historical photographs. Two main accumulations of tailings are evident, one right at the mill site, and the other about 2,000 feet down the valley where tailings had apparently collected behind a dam.

Modern Mining

The Horeshoe Pit was excavated from 1993 to 1994 along the divide between Barnes-King Gulch and Little Dog Creek. The waste was placed in the Horseshoe waste rock dump at the head of Little Dog Creek. In addition, the North Muleshoe waste rock dump was loaded (1990-94) within the Muleshoe branch of Little Dog Creek.

The waste rock dumps were re-graded, capped and re-vegetated between 1994 and 1996, while a seepage collection system (KVPB-6) was installed at the toe of the North Muleshoe waste rock dump in 1996.

Waste Disturbance

According to one source (Gallagher, 2002), the Horseshoe dump was constructed directly on top of the North Moccasin Syndicate tailings, while another source (WMC, 1999) states that the tailings were removed prior to construction in 1991-92. The off-site tailings behind the dam were not removed, as they are clearly evident in the 1997 air photo.

3.5.2 Sediment Quality

Water and Environment Technologies (2002) collected a sample of tailings from the material collected behind the dam (referred to as the "North Fork Lower Tailings Dam"). The WET results are reproduced in Table 3.5-1.

Table 3.5-1
North Fork Little Dog Creek Tailings Analysis[1]

Parameter	Value (mg/kg)
Arsenic	264
Iron	15,500
Selenium	NA
Thallium	<50
Zinc	231

NA = Not analyzed

[1] Data collected by WET (2002)

The arsenic concentration in the tailings is relatively high and would account for the water analyses above the WQB-7 criteria for arsenic in the few waters in the area that could be associated with historic tailings (assuming all of the historical tailings are similar). The low thallium is also consistent with waters in association with historical tailings. However, it should be pointed out that total concentrations in a solid cannot always be related to leachability.

3.5.3 Water Quality

Unfortunately, no piezometers were installed within the N. Moccasin Syndicate tailings by WET. However, a surface water sample was collected from behind the dam. The results are presented in Table 3.5-2.

Table 3.5-2
North Fork Little Dog Creek Tailings Dam Surface Water Results[1]

Parameter[2]	WQB-7 Criteria[3]	Value (Totals for metals)
SC (μmho/cm)	---	212
Sulfate	---	36
Nitrate/nitrite as N	10	0.11
Arsenic	0.018	**0.078**
Iron	---	0.96
Selenium	0.005	<0.001
Thallium	0.0017	**0.003**

[1] Data collected by WET (2002).

[2] Units are mg/L unless otherwise noted.

[3] The lowest value between the human health surface water and chronic aquatic standards.

Note: Bold values indicate the WQB-7 criteria is exceeded (aquatic or human health).

The low sulfate and thallium values and relatively high arsenic concentration is consistent with the data from the Peters Spring. The data also suggest that leachability is roughly proportional to the total concentrations in the tailings. The slightly elevated nitrate/nitrite concentration is not unusual for a surface water or shallow groundwater in the area.

3.5.4 Conclusion

High quality water introduced into the North Fork of Little Dog Creek would interact with the historical tailings and result in elevated arsenic concentrations in the water. Water which is piped beyond the tailings dam would likely interact with sediments in Little Dog Creek which have interacted with low quality water from the modern and historical mining activities. WET (2002) measured an arsenic concentration of 0.625 mg/L and selenium and thallium concentrations of 0.016 mg/L and 0.057 mg/L, respectively, in the porewaters of the S. Fork of Little Dog Creek (also referred to as the Muleshoe Branch). Therefore, the sediments are likely impacted by the low quality water. Arsenic, selenium and thallium would desorb from any impacted sediments and adversely affect a treated or high quality water introduced into the drainage, especially in the upper reaches.

3.6 Dog Creek

3.6.1 Mining/Milling Operations

Historical Mines

The Barnes-King Development Company operated the North End Mine at the head of Dog Creek (on the north side of the drainage). The Abbey Mine is shown on the USGS topographic map (USGS, 1985) in this area. Either the north end mine is located nearby and is not shown on the topographic map or the two names were used to describe the same mine. In any case, a small quantity of waste rock was likely deposited adjacent to the mine(s).

Modern Mining

The Dog Creek drainage is outside of the permit boundary and does not appear to have been significantly impacted by modern mining. A disturbed area of approximately two acres is present within the drainage.

3.6.2 Sediment Quality

No sediment data have been collected in the Dog Creek drainage as far as is known.

3.6.3 Water Quality

The lack of modern mining and significant historical mining impacts on Dog Creek is reflected in the quality of the surface water measured in the drainage. DEQ measured the stream flow in the drainage in June 1998 and did not obtain any values above the WQB-7 criteria for arsenic, selenium or thallium. The lower background levels compared to the N. Fork may be due to the different background trace element concentrations of the two drainages.

3.6.4 Conclusion

High quality or treated water introduced into Dog Creek would likely remain high quality.

3.7 Summary

The following drainages have been impacted by historical tailings/waste rock, or modern waste rock and low quality waters:

- Barnes-King (historical tailings, waste rock, low quality waters).
- Mason Canyon (historical tailings, low quality waters).
- Little Dog Creek (historical tailings, waste rock, low quality waters).
- S. Fork Last Chance Gulch (waste rock/low quality water).
- N. Fork Last Chance Gulch (low quality water, potentially historical or modern waste rock).

Dog Creek is the only drainage that appears to have minimal impacts from historical or modern mining activities. In addition, the natural rock and soils in this drainage appears to result in low background levels of arsenic, selenium and thallium.

Section 4
Recommendations

With the exception of Big Dog Creek, all of the drainages investigated have been heavily impacted by historical and/or modern mining wastes or by interaction of the natural sediments with low quality water generated from such wastes. Given the very low chronic aquatic standards for selenium (0.005 mg/L) and the low human health standards for arsenic (0.018 mg/L) and thallium (0.0017 mg/L) even a mildly impacted sediment could result in contamination of a high quality water introduced into these drainages. Therefore, it is recommended that measures be taken to prevent contact between the high quality water and the impacted sediments within the drainages.

Section 5
References

Anonymous, 1904. The Mines of Judith Basin Montana. The Engineering and Mining Journal. Vol. 78 no. 3, p. 96.

Anonymous, 1904b. Mining in Fergus County, Montana. The Mining World. Vol. 20, no. 22, p. 23-26.

Blixt, John E., 1933. Geology and Gold Deposits of the North Moccasin Mountains, Fergus County, Montana. Memoir No. 8 MBMG February, 1933.

CR Kendall, 2003. Memo from Glen Pegg to Kent Whiting dated October 6, 2003.

CR Kendall, 2002. Kendall Mine Permit #00122 Annual Progress Report for the Year 2001 Water Resources Monitoring.

C. R. Kendall 1996. Barnes-King Tailings leachate analytical results

CR Kendall, 1988. The Kendall News, 1898-1988 (Promotional material published by the mining company).

Gallagher, K., 2002. Flowpath Evaluation for the CR Kendall Mine Area Fergus County, Montana.

Montana Bureau of Mines and Geology (MBMG), 1940. Directory of Montana Mining Properties. WPA Mineral Resources Survey O. P. 65-1-91-24 W. P. 2986).

___________________________, 1942. Bibliography of the Geology and Mineral Resources of Montana. WPA Mineral Resources Survey O. P. 265-91-1-47 W. P. 3622).

Montana Historical Society, 1909. Kendall Area Claim Map with mine production figures appended at a later date. MHS map 1503.

Montana Historical Society, 1974. Kendall: Twentieth Century Ghost Town. Montana the Magazine of Western History. Volume XXIV, No. 2, Spring, 1974. p. 68-84.

Sanborn, 1902. Kendall, Montana Fire Insurance Map, 1902.

Sanborn, 1905. Kendall, Montana Fire Insurance Map, 1905.

Sanborn, 1908. Kendall, Montana Fire Insurance Map, 1908.

Unknown, c.1997. Low Altitude Aerial Photograph (Covers portions of the Kendall Quadrangle, MT).

Unknown, 1988. Low Altitude Aerial Photograph (Covers portions of the Kendall Quadrangle, MT).

U. S. Department of Agriculture, 1938. Low Altitude Aerial Photograph (Covers portions of the Kendall Quadrangle, MT).

U. S. Geological Survey (USGS), 1985. 7 ½ Minute Topographical Map of the Kendall Quadrangle, Montana.

Water & Environmental Technologies (WET), 2002. Extent of Contamination Investigation Little Dog Creek Drainage Fergus County, Montana.

Water Management Consultants (WMC), 1999. Evaluation of Background Hydrochemistry for the Kendall Mine.

Appendix A
July 2003 Sampling Event

Field Activity Methods and Procedures

The following is a summary of field activities that was performed by CDM and Tetra Tech personnel during the 2003 site investigation. Field procedures and protocol are described in the following subsections.

Surface Water/Well sampling

Water samples were collected from the ponds (Jack Ruckman, Lewis Harrel and Boy Scout), CR Kendall pumpback wells, and area springs. The pump back wells were sampled using a PVC sampler (provided by the mine) consisting of a capped 1-2 foot section of 6 inch diameter PVC pipe connected to a long section of 1.25 inch PVC. The long section of PVC was used to lower the 6 inch diameter sampling vessel into the well. A valve was placed in the cap of the sampler to allow water to be drained into the sample bottles or into the filter.

The spring samples were collected directly from the pipe discharge (if present) or from the pool (stock tank) into a 5 gallon bucket. The bottles were filled from the bucket immediately following collection. A new bucket of water was collected to obtain the field parameters.

The samplers/buckets were rinsed 3 times with water from the new location prior to sampling.

The samples were analyzed for the following:

- pH
- Eh
- Temperature
- DO
- Antimony
- Arsenic
- Calcium
- Iron
- Selenium
- Sodium
- Thallium
- Total cyanide
- Weak Acid Dissociable (WAD) cyanide

The following samples were collected:

Sample ID	Type	Location
CRK-KVPB6-01	Pumpback Wells	Down-gradient of the North Muleshoe waste rock dump in the Little Dog drainage basin.
CRK-KVPB5-1		Down-gradient of the Muleshoe waste rock dump in the Barnes-King drainage
CRKVPB2-01		Collects Seepage from the Kendall Waste Rock dump
CRK-TMW26-01		Springs beneath Leach Pad #4 – Mason Canyon drainage
CRK-JRS-1	Jack Ruckman Spring	Jack Ruckman Property – S. Fork of Last Chance Creek
CRK-TSP-1	Town Spring	Town of Kendall (aka Kendall Spring #2) – N. Fork Last Chance Creek drainage
CRK-TSP1-1	Town Spring (Duplicate)	
CRK-SP29-01	Section 29 Spring	Little Dog drainage
CRK-BSPW-1	Pond Water	Boy Scouts – S. Fork of Last Chance Creek drainage
CRK-LHP-1	Pond Water	Lewis Harrel Property – S. Fork of Last Chance Creek drainage
CRK-JRP-1	Pond Water	Jack Ruckman Property – S. Fork of Last Chance Creek drainage

Sediment Sampling

Sediment samples (3 total) were collected from area ponds, including the Boy Scout pond, Jack Ruckman Pond, and the Lewis Harrel Pond. The samples were analyzed for the following:

- Arsenic
- Selenium
- Thallium

Samples were collected using 10 foot sections of 1.25 inch PVC pipe. For each location a new section of PVC was pushed into the pond sediment. An end cap was then placed over the protruding end of the pipe to create a vacuum allowing the pipe and the sediment core to be extracted. The core was removed from the pipe using a 10 foot section of 1 inch PVC fitted with an end cap. The smaller diameter PVC was used as a plunger to push the core section directly into a sample jar.

The following samples were collected:

Sample ID	Location
CRK-BSP-1	Boy Scout Pond
CRK-JRP-1	Jack Ruckman Pond
CRK-LHP-1	Lewis Harrel Pond

Appendix B
Summary of July 2003 Sampling Results

The results of the spring sampling are shown in Table B-1. Selenium concentrations in the section 29 spring exceeded the WQB-7 aquatic standard of 0.005 mg/L. Detectable total cyanide concentrations in the section 29 Spring, while below the standard are troubling in that it may indicate that cyanide is migrating from the site.

Table B-1
Spring Sample Results (mg/L)
July 2003

	CRK- SP29-01 (Section 29)	CRK-JRS-1 (Jack Ruckman)	CRK-TSP-1 (Kendall #2)	CRK-TSP1K-1 (Kendall #2 Duplicate)	WQB-7 (Surface Water)
pH (su)	6.9	7.10	7.45	-	
Specific Conductace (umho/cm)	1.70	0.61	0.94	-	
Temperature (°C)	12.3	13.0	12.3	-	
ORP (mv)	17	123	150	-	
Antimony	<0.003	<0.003	<0.003	<0.003	0.006
Arsenic	0.001	<0.001	<0.001	<0.001	0.018
Calcium	256	89	120	121	-[2]
Iron	<0.03	<0.03	<0.03	<0.03	-
Selenium	**0.007**	0.001	0.002	0.002	0.005[3]
Sodium	9	6	4	4	-
Thallium	<0.001	<0.001	<0.001	<0.001	0.0017
Cyanide (T)	0.013	NA[1]	<0.005	<0.005	0.200
Cyanide (WAD)	<0.005	NA	<0.005	<0.005	-

[1] *NA = Not analyzed*

[2] *"-" indicates no Human Health WQB-7 Criteria exists*

[3] *WQB-7 Aquatic Criteria (chronic)*

*Note: **Bold** indicates result exceeds the WQB-7 Criteria*

ORP = Oxidation Reduction Potential

The results of the pond water sampling are shown in Table B-2.

Table B-2
Pond Sample Results (mg/L)
July 2003

	CRK-JRP-1 (Jack Ruckman)	CRK-LHP-1 (Lewis Harrel)	CRK-BSPW-1 (Boy Scouts)	WQB-7 (Surface Water)
pH (su)	8.16	7.80	7.8	
Specific Conductace (umho/cm)	0.61	0.918	0.91	
Temperature (°C)	27.3	25.2	25.8	
ORP (mv)	90	111	86	
Antimony	<0.003	<0.003	<0.003	0.006
Arsenic	0.003	0.015	**0.021**	0.018
Calcium	73	148	152	-[1]
Iron	<0.03	<0.03	<0.03	-
Selenium	<0.001	<0.001	<0.001	0.005
Sodium	7	6	6	-
Thallium	<0.001	<0.001	<0.001	0.0017

[1] *"-" indicates no Human Health WQB-7 Criteria exists*

*Note: **Bold** indicates result exceeds the WQB-7 Human Health Criteria*

ORP = Oxidation Reduction Potential

The Boy Scout pond results exceeded the WQB-7 surface water standard for arsenic (0.018 mg/L). All other samples were within acceptable limits for the parameters analyzed.

The results of the pump-back well analyses are shown in Table B-3.

Table B-3
Pumpback Well Sample Results (mg/L)
July 2003

	KVPB6-01 (Little Dog)	KVPV5-1 (Barnes-King)	TMW26-1 (Mason Canyon)	KVPB2-1 (S. Fork)	WQB-7 (Groundwater)
pH (su)	6.9	7.1	6.8	6.3	
Specific Conductace (umho/cm)	2.83	3.44	1.70	3.29	
Temperature (°C)	10.9	12.81	10.73	13.02	
ORP (mv)	108	124	145	191	
Antimony	<0.003	<0.003	<0.003	0.005	0.006
Arsenic	0.006	0.003	0.003	0.009	0.020
Calcium	396	414	216	486	-[1]
Iron	<0.03	0.21	<0.03	0.16	-
Selenium	**0.027**	**0.012**	**0.012**	**0.009**	0.005[2]
Sodium	53	11	26	58	-
Thallium	**0.327**	**0.034**	**0.031**	**1.364**	0.002
Cyanide (T)	0.018	<0.005	0.019	0.017	0.200
Cyanide (WAD)	0.006	<0.005	<0.005	<0.005	-

[1] "-" indicates no Human Health WQB-7 Criteria exists

[2] WQB-7 Aquatic Criteria (chronic), the human health standard for groundwater is 0.050 mg/L

*Note: **Bold** indicates result exceeds the WQB-7 Criteria*

ORP = Oxidation Reduction Potential

All of the pump-back wells exceeded the WQB-7 criteria for selenium (chronic aquatic) and thallium (human health).

Table B-4
Pond Sediment Sample Results (mg/kg)
July 2003

Parameter[1]	CRK-JRPS-01 (Jack Ruckman)	CRK-LHP-1 (Lewis Harrel)	CRK-BSPS-1 (Boy Scouts)
Antimony	<5	<5	<5
Arsenic	2.7	3.4	2.3
Boron	16.7	14.2	8.3
Copper	16.2	8.6	8.5
Iron	14200	10300	4680
Manganese	292	416	358
Molybdenum	<5	<5	<5
Nickel	12.7	8.4	4.1
Selenium	<1	<1	<1
Sodium	<100	<100	103
Thallium	<1	<1	<1
Zinc	44.2	28.4	16

[1] Units in mg/kg

The pond sediments have very low concentration of arsenic, and values below the reporting limit of the laboratory for thallium and selenium.